CURRENT ELECTRICITY

Contents

Syllabus

Electric Current ; Ohm's law ; Seres and parallel arrangements of resistances and cells ; Kirchhoff's laws and simple applications ; Heating effect of current.

CURRENT ELECTRICITY

- $I_{av} = \frac{\Delta q}{\Delta t}$ and $i_{inst.} = \frac{dq}{dt} \Rightarrow q = \int idt$ = area between current – time graph on time axis.
- Current $i = neAV_d$ n = no. of free electron per unit volume, A = cross - section area of conductor, V_d = drift velocity, e = charge on electron = 1.6×10^{-19} C
- Ohm's law V = IR
- $R = \frac{\rho \ell}{A}$ ρ = resistivity = $\frac{1}{\sigma}$, σ = conductivity
- Power P = VI $\Rightarrow$ $P = I^2R = \frac{V^2}{R}$
- Energy = power × time (if power is constant.) otherwise energy, $E = \int P.dt$ where P is power.
- The rate at which the cemical energy of the cell in consumed = Ei
- The rate at which heat is generated inside the battery = i^2r
- Electric power output = $(\varepsilon - ir)\,i$
- Maximum power output when net internal resistance = net external resistanc, R = r

  Maximum power output = $\frac{\varepsilon^2}{4r}$
- In series combination $R = R_1 + R_2 + R_3 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$
- In parallel combination $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$
- Cell in series combination
- $E_{eq} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 + \ldots\ldots\ldots\ldots\ldots\ldots + \varepsilon_n$ (write Emf's with polarity)
- $r_{eq} = r_1 + r_2 + r_3 + \ldots\ldots\ldots\ldots\ldots\ldots$
- Cells in parallel combination

  $$E_{eq} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \ldots\ldots\ldots + \frac{\varepsilon_n}{r_n}}{\frac{1}{r_1} + \frac{1}{r_1} + \ldots\ldots\ldots + \frac{1}{r_n}}$$ (Use proper sign before the EMFs for polarity

  and $\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \ldots\ldots\ldots\ldots\ldots + \frac{1}{r_n}$
- In ammeter shunt (S) = $\frac{I_G \times R_G}{I - I_G}$
- In voltmeter $V = I_GR_S + I_GR_G$
- Potential gradient in potentiometer : $x = \frac{\varepsilon}{R + r} \times \frac{R}{L}$

EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

* *Marked Questions are having more than one correct option.*

Section (A) : Current, current Density, drift velocity

A-1. The current in a wire varies with time according to the equation i =4 +2 t, where i is in ampere and t is in sec. The quantity of charge which has passed through a cross-section of the wire during the time $t = 2$ s to $t = 6$ s

(A) 42 C (B) 44 C (C) 48 C (D) 54 C

A-2. Two wires each of radius of cross section r but of different materials are connected together end to end (in series). If the densities of charge carriers in the two wires are in the ratio 1 : 4, the drift velocity of electrons in the two wires will be in the ratio:

(A) 1 : 2 (B) 2 : 1 (C) 4 : 1 (D) 1 : 4

A-3. The drift velocity of electrons in a conducting wire is of the order of 1mm/s, yet the bulb glows very quickly after the switch is put on because

(A) The random speed of electrons is very high, of the order of 10^6 m/s

(B) The electrons transfer their energy very quickly through collisions

(C) Electric field is set up in the wire very quickly, producing a current through each cross section, almost instantaneously

(D) All of above

A-4. In the presence of an applied electric field ($\vec{E}$) in a metallic conductor.

(A) The electrons move in the direction of $\vec{E}$

(B) The electrons move in a direction opposite to $\vec{E}$

(C) The electrons may move in any direction randomly, but slowly drift in the direction of $\vec{E}$.

(D) The electrons move randomly but slowly drift in a direction opposite to $\vec{E}$.

A-5. An insulating pipe of cross-section area 'A' contains an electrolyte which has two types of ions→ their charges being –e and +2e. A potential difference applied between the ends of the pipe result in the drifting of the two types of ions, having drift speed = v (–ve ion) and v/4 (+ve ion). Both ions have the same number per unit volume = n. The current flowing through the pipe is

(A) nev A/2 (B) nev A/4 (C) 5nev A/2 (D) 3nev A/2

Section (B) : Resistance & Resistivity

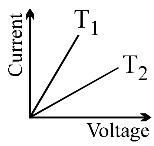
B-1. If a wire is stretched so that its length increases by 0.1 %, the percentage change in its resistance will be

(A) 0.1 % (B) 0.2 % (C) 0.3 % (D) 0.4 %

B-2. The resistance of a rectangular block of copper of dimensions 1 mm × 1 mm × 5 m between two square faces is 0.08 Ω. What is the resistivity of copper ?

(A) 1.6×10^{-7} Ω-m (B) 1.6×10^{-6} Ω-m (C) 1.6×10^{-8} Ω-m (D) Infinite

B-3. The current in a metallic conductor is plotted against voltage at two different temperatures T_1 and T_2. Which is correct



(A) $T_1 > T_2$ (B) $T_1 < T_2$

(C) $T_1 = T_2$ (D) none

B-4. The temperature co-efficient of resistance of a wire is 0.00125°C^{-1}. At 300K its resistance is 2Ω. The resistance of the wire will be 2.5 Ω at temperature about

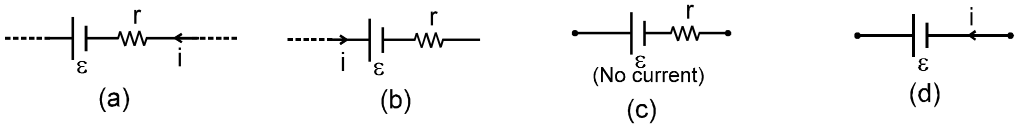
(A) 120°C (B) 234°C (C) 310°C (D) 27°C

B-5. A wire of cross-section area A, length L_1, resistivity ρ_1 and temperature coefficient of resistivity α_1 is connected to a second wire of length L_2, resistivity ρ_2, temperature coefficient of resistivity α_2 and the same area A, so that wire carries same current. Total resistance R is independent of temperature for small temperature change if (Thermal expansion effect is negligible)

(A) $\alpha_1 = -\alpha_2$ (B) $\rho_1 L_1 \alpha_1 + \rho_2 L_2 \alpha_2 = 0$

(C) $L_1 \alpha_1 + L_2 \alpha_2 = 0$ (D) None

Section (C) : Power energy EMF Battery Kirchoffs law

C-1. 

In which of the above cells, the potential difference between the terminals of a cell exceeds its emf.

(A) a (B) b (C) c (D) d

C-2. In an electric circuit containing a battery, the positive charge inside the battery

(A) always goes from the positive terminal to the negative terminal

(B) may go from the positive terminal to the negative terminal

(C) always goes from the negative terminal to the positive terminal

(D) does not move

C-3. Two electric lamps A and B having power 200 watt and 100 watt respectively are rated on the same voltage. The ratio of resistance of lamp A to that of B is :

(A) 1 : 2 (B) 2 : 1 (C) 1 : 4 (D) 4 : 1

C-4. Four equal resistors, when connected in series, dissipate a power of 5 watts. If these resistors are connected in parallel, the power dissipated will be :

(A) 20 watts (B) 40 watts (C) 50 watts (D) 80 watts

C-5. Two bulbs one of 200 volts, 60 watts & the other of 200 volts, 100 watts are connected in series to a 200 volt supply. The power consumed will be

(A) 37.5 watt (B) 160 watt (C) 62.5 watt (D) 110 watt

C-6. A resistor of resistance R is connected to a cell of internal resistance 5 Ω. The value of R is varied from 1 Ω to 5 Ω. The power consumed by R :

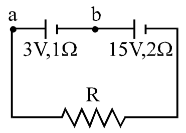
(A) increases continuously (B) decreases continuously

(C) first decreases then increases (D) first increases then decreases.

C-7. Two bulbs rated (25 W – 220V) and (100W – 220V) are connected in series to a 440 V line. Which one is likely to fuse ?

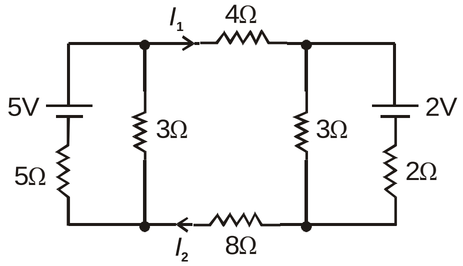
(A) 25 W bulb (B) 100 W bulb (C) both bulbs (D) none of these.

C-8. Two batteries one of the emf 3V, internal resistance 1 ohm and the other of emf 15 V, internal resistance 2 ohm are connected in series with a resistance R as shown. If the potential difference between a and b is zero the resistance of R in ohm is



(A) 5 (B) 7 (C) 3 (D) 1

C-9. In the circuit shown, the ratio $\frac{I_1}{I_2}$ is equal to -



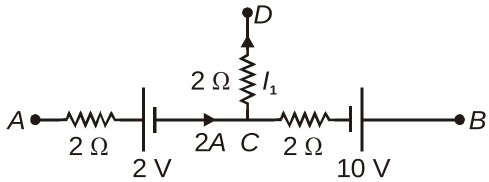
(A) 4.0

(B) 3.0

(C) 2.5

(D) 1.0

C-10. A part of a circuit is shown in figure. $V_B - V_C$ is equal to 12 V. I_1 is equal to



(A) 1 A

(B) 2 A

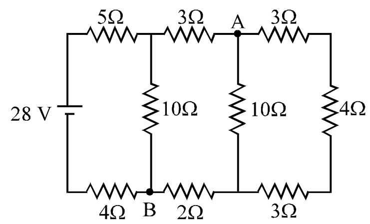
(C) 3 A

(D) 4 A

C-11. If the length of the filament of a heater is reduced by 10%, the power of the heater will

(A) increase by about 9%
(B) increase by about 11%
(C) increase by about 19%
(D) decrease by about 10%

C-12. Consider the circuit shown in the figure



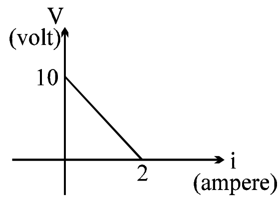
(A) the current in the 5 Ω resistor is 2 A

(B) the current in the 5 Ω resistor is 1 A

(C) the potential difference $V_A - V_B$ is 10 V

(D) the potential difference $V_A - V_B$ is 5 V

C-13. A battery of emf E and internal resistance r is connected across a resistance R. Resistance R can be adjusted to any value greater than or equal to zero. A graph is plotted between the current (i) passing through the resistance and potential difference (V) across it. Select the correct alternative(s).



(A) internal resistance of battery is 5Ω

(B) emf of the battery is 20V

(C) maximum current which can be taken from the battery is 4A

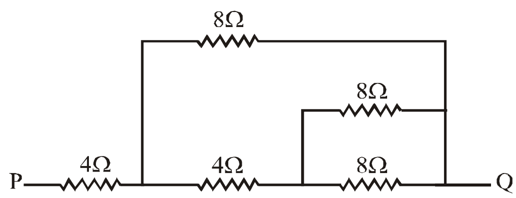
(D) V- i graph can never be a straight line as shown in figure.

C-14. An electric current is passed through a circuit containing three wires arranged in parallel. If the length and radius of the wires are in ratio 2 : 3 : 4 and 3 : 4 : 5, then the ratio of current passing through wires would be:

(A) 54 : 64 : 75
(B) 9 : 16 : 25
(C) 4 : 9 : 25
(D) 3 : 6 : 10.

Section (D) : Combination of Resister

D-1. The resistance between P and Q in the following combination of resistances is



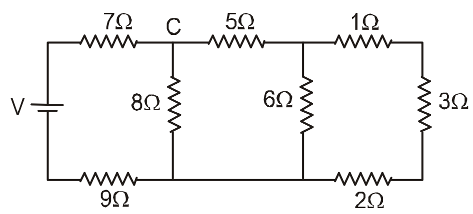
(A) 8 Ω

(B) 6 Ω

(C) 5 Ω

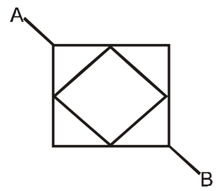
(D) 4 Ω

D-2. In the ladder network shown, current through the resistor 3 Ω is 0.25 A. The input voltage 'V' is equal to



(A) 10 V (B) 20 V (C) 5 V (D) $\frac{15}{2}$ V

D-3. A wire has linear resistance λ (in Ohm/m). Find the resistance R between points A and B if the side of the "big" square is d :



(A) $\frac{\lambda d}{\sqrt{2}}$ (B) $\sqrt{2}\ \lambda d$

(C) $2\lambda d$ (D) None of these

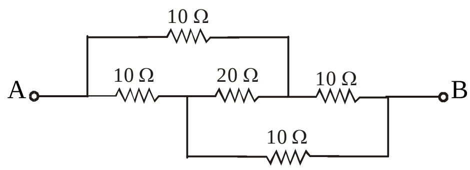
D-4. The equivalent resistance between the points A and B of the following circuit is

(A) 5 Ω

(B) 10 Ω

(C) 15 Ω

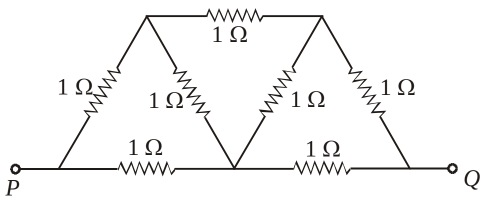
(D) 20 Ω



D-5. Seven resistors, each of 1 Ω, are connected as shown in the figure. The effective resistance between P and Q is

(A) $\frac{4}{3}\Omega$ (B) $\frac{8}{7}\Omega$

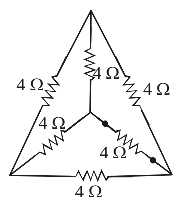
(C) $\frac{3}{2}\Omega$ (D) 7 Ω



D-6. If σ_1, σ_2 and σ_3 are conductances of three conductors of identical shape and size, then their equivalent conductance when they are joined in series will be

(A) $\sigma_1 + \sigma_2 + \sigma_3$ (B) $\frac{1}{\sigma_1} + \frac{1}{\sigma_2} + \frac{1}{\sigma_3}$ (C) $\frac{\sigma_1\sigma_2\sigma_3}{\sigma_1 + \sigma_2 + \sigma_3}$ (D) None of these

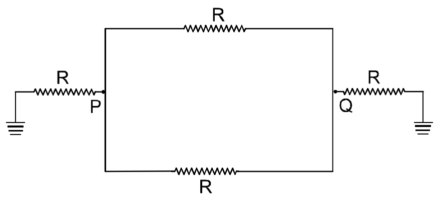
D-7. Six resistances, each equal to 4 Ω are connected as shown in the figure. The effective resistance between any two vertices is



(A) 2 Ω (B) 8 Ω

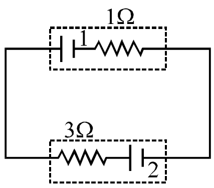
(C) 12 Ω (d) 16 Ω

D-8. The resistance between P and Q in the shown circuit is :



(A) $\frac{R}{2}$ (B) $\frac{2R}{5}$ (C) $\frac{3R}{5}$ (D) $\frac{R}{3}$

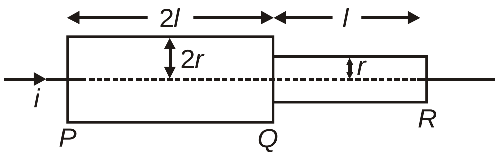
D-9. In the figure shown, battery 1 has emf = 6 V and internal resistance = 1 Ω. Battery 2 has emf = 2V and internal resistance = 3 Ω. The wires have negligible resistance. What is the potential difference across the terminals of battery 2 ?



(A) 4 V (B) 1.5 V

(C) 5 V (D) 0.5 V

D-10. Two bars made of same material are connected as shown in the figure. An electric current is passed through the bars. Resistance of bar *PQ* is R_1 while resistance of *QR* is R_2, then



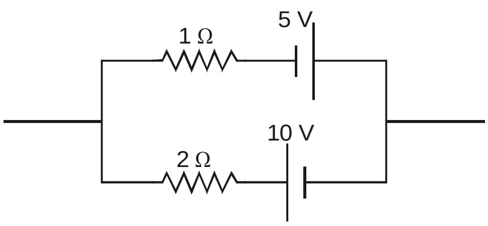
(A) $2R_1 = R_2$ (B) $2R_2 = R_1$ (C) $4R_2 = R_1$ (D) $R_2 = 4R_1$

Section (E) : Combination of Cells

E-1. Five cells each of internal resistance 0.2Ω and e.m.f. 2V are connected in series with a resistance of 4Ω. The current through the external resistance is

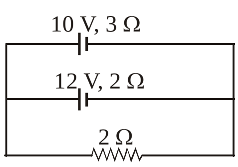
(A) 0.2 A (B) 0.5 A (C) 1 A (D) 2 A

E-2. The emf of a single battery which is equivalent to a parallel combination of two batteries of emfs 5 V and 10 V and internal resistances 1 Ω and 2 Ω respectively connected as shown in figure is



(A) 5 V (B) 10 V (C) Zero (D) 15 V

E-3. The current through the resistor in the given circuit is



(A) 1.5 A

(B) 2.5 A

(C) 3.5 A

(D) 5.0 A

E-4. 12 cells each having the same emf are connected in series and are kept in a closed box. Some of the cells are wrongly connected. This battery is connected in series with an ammeter and two cells identical with each other and also identical with the previous cells. The current is 3 A when the external cells aid this battery and is 2 A when the cells oppose the battery. How many cells in the battery are wrongly connected?
(A) one (B) two (C) three (D) none

E-5.* N cells each of e.m.f. E & identical resistance r are grouped into sets of K cells connected in series. The (N/K) sets are connected in parallel to a load of resistance R, then;

(A) Maximum power is delivered to the load if $K = \sqrt{\frac{NR}{r}}$.

(B) Maximum power is delivered to the load if $K = \sqrt{\frac{r}{NR}}$

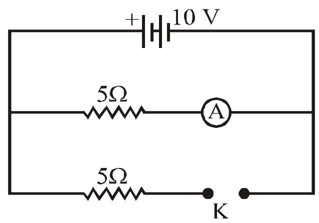
(C) Maximum power delivered to the load is $\frac{NE^2}{4r}$

(D) Maximum power delivered to the load is $\frac{E^2}{4Nr}$

Section (F) : Instruments

F-1. Mark out the correct options.
(A) An ammeter should have small resistance. (B) An ammeter should have large resistance.
(C) A voltmeter should have small resistance. (D) A voltmeter should have large resistance.

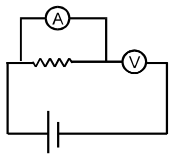
F-2. Assume that the internal resistance of battery is zero and the key is closed in the following circuit, the reading of the ammeter is



(A) 0.25 A
(B) 0.5 A
(C) 1.0 A
(D) 2.0 A

F-3. When a galvanometer is shunted with a 4Ω resistance, the deflection is reduced to one - fifth. If the galvanometer is further shunted with a 2Ω wire, determine current in galvanometer now if initially current in galvanometer is I_0 (given main current remain same) .
(A) $I_0/13$ (B) $I_0/5$ (C) $I_0/8$ (D) $5I_0/13$

F-4.* By mistake, a voltmeter is placed in series and an ammeter in parallel with a resistance in an electric circuit, with a cell in series.

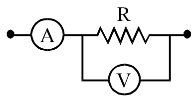


(A) The main current in the circuit will be very low and almost all current will flow through the ammeter, if resistance of ammeter is much smaller than the resistance in parallel.
(B) If the devices are ideal, a large current will flow through the ammeter and it will be damaged
(C) If the devices are ideal, ammeter will read zero current and voltmeter will read the emf of cell
(D) The devices may get damaged if emf of the cell is very high and the meters are nonideal.

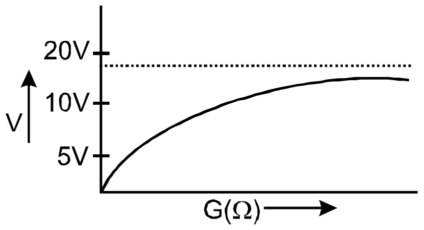
F-5. In the circuit shown the readings of ammeter and voltmeter are 4A and 20V respectively. The meters are non ideal, then R is :

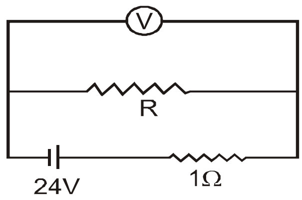
(A) 5Ω (B) less than 5Ω

(C) greater than 5Ω (D) between 4Ω & 5Ω



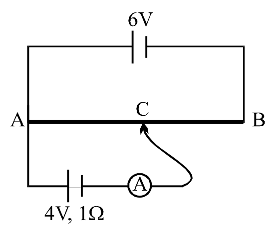
F-6. A cell of internal resistance $1\,\Omega$ is connected across a resistor. A voltmeter having variable resistance G is used to measure p.d. across resistor. The plot of voltmeter reading V against G is shown. What is value of external resistor R ?





(A) 5Ω (B) 4Ω (C) $3\,\Omega$ (D) 1Ω

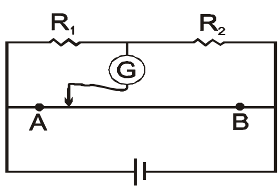
F-7. A 6 V battery of negligible internal resistance is connected across a uniform wire of length 1 m. The positive terminal of another battery of emf 4V and internal resistance $1\,\Omega$ is joined to the point A as shown in figure. The ammeter shows zero deflection when the jockey touches the wire at the point C. The AC is equal to



(A) 2/3 m (B) 1/3 m

(C) 3/5 m (D) 1/2 m

F-8. In the figure shown for given values of R_1 and R_2 the balance point for Jockey is at 40 cm from A. When R_2 is shunted by a resistance of $10\,\Omega$, balance shifts to 50 cm. R_1 and R_2 are (AB = 1 m) :



(A) $\frac{10}{3}\Omega,\ 5\Omega$ (B) $20\Omega,\ 30\Omega$ (C) $10\Omega,\ 15\Omega$ (D) $5\Omega, \frac{15}{2}\Omega$

F-9.* In a potentiometer wire experiment the emf of a battery in the primary circuit is 20 V and its internal resistance is 5Ω. There is a resistance box in series with the battery and the potentiometer wire, whose resistance can be varied from 120Ω to 170Ω. Resistance of the potentiometer wire is 75Ω. The following potential differences can be measured using this potentiometer.

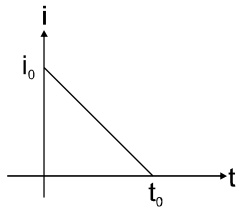
(A) 5V (B) 6V (C) 7V (D) 8V

PART - II : MISCELLANEOUS OBJECTIVE QUESTIONS

Comprehensions Type :

Comprehension # 1

Relation between current in conductor and time is shown in Figure, then determine:



1. Total charge flown through the conductor is :

(A) $i_0t_0/2$ (B) i_0t_0 (C) $i_0t_0/4$ (D) $2i_0t_0$

2. Write the expression of current in terms of time.

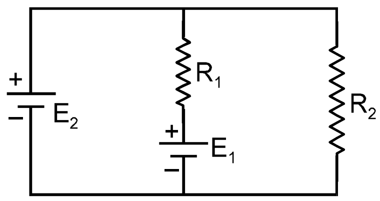
(A) $i = i_0\,\frac{t}{t_0}$ (B) $i = i_0\left(1+\frac{t}{t_0}\right)$ (C) $i = i_0\left(\frac{t}{t_0}-1\right)$ (D) $i = i_0\left(1-\frac{t}{t_0}\right)$

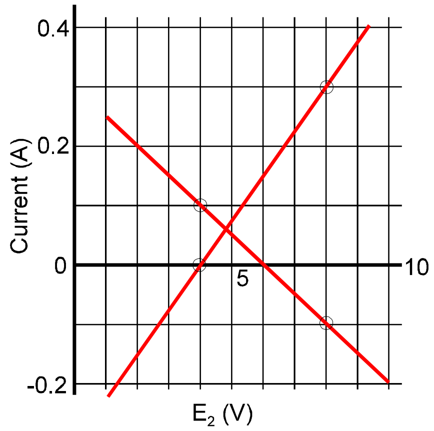
3. If the resistance of conductor is R, then total heat dissipated across resistance R is

(A) $\frac{i_0^2Rt_0}{2}$ (B) $\frac{i_0^2Rt_0}{4}$ (C) $\frac{i_0^2Rt_0}{3}$ (D) $i^2{}_0Rt_0$

Comprehension # 2

In the circuit given below, both batteries are ideal. Emf E_1 of battery 1 has a fixed value, but emf E_2 of battery 2 can be varied between 1.0 V and 10.0 V. The graph gives the currents through the two batteries as a function of E_2, but are not marked as which plot corresponds to which battery. But for both plots, current is assumed to be negative when the direction of the current through the battery is opposite the direction of that battery's emf. (direction of emf is from negative to positive)





4. The value of emf E_1 is

(A) 8 V (B) 6 V (C) 4 V (D) 2V

5. The resistance R_1 has value

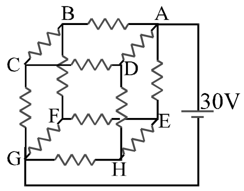
(A) 10 Ω (B) 20 Ω (C) 30 Ω (D) 40 Ω

6. The resistance R_2 is equal to :

(A) 10 Ω (B) 20 Ω (C) 30 Ω (D) 40 Ω

Comprehension # 3

A resistor circuit is constructed such that twelve resistors are arranged to form a cube as shown in figure. Each resistor has a resistance of 2 ohm. The potential difference of 30 V is applied across two of the opposing points as shown.



7. The points having the same potential are :

(a) B, D, E (b) C, F, H (c) C, E

(A) only (a) is correct (B) (a), (b) and (c) are correct

(C) only (b) is correct (D) (a) and (b) both are correct

8. If we replace resistors between A and B and resistors between G and H by resistors with wires of zero resistance, then the points having the same potential are :

(a) D, E, C, F (b) A, B (c) G, H

(A) only (a) is correct (B) only (b) is correct

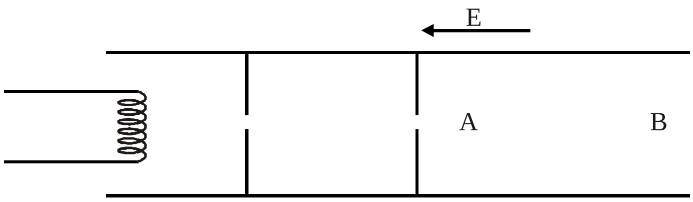
(C) only (c) is correct (D) (a), (b), (c) are correct

9. In the above question, the potential difference between the points C and G is :

(A) 15 V (B) 10 V (C) 20 V (D) 7.5 V

Match the Column :

10. Electrons are emitted by a hot filament and are accelerated by an electric field as shown in figure. The two stops at the left ensure that the electron beam has a uniform cross-section. Match the entries of column-I with column-II as electron move from A to B :



Column-I		**Column-II**	
(A)	Speed of an electron	(p)	Inreases
(B)	Number of free electrons per unit volume	(q)	Decreases
(C)	Current density	(r)	Remains same
(D)	Electric potential	(s)	any of the above is possible

EXERCISE # 2

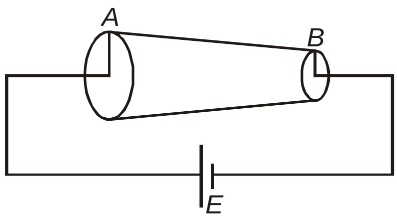
PART - I : OBJECTIVE QUESTIONS

1. A wire is connected to a battery and drift velocity of electrons in the wire is *v*. Now, the wire is stretched to double its length and connected to same battery. The drift velocity of electrons in the new wire will become/ remain

(A) v (B) $4v$ (C) $\frac{v}{2}$ (D) $2v$

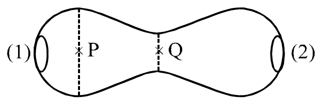
2. A current, 16 A, is made to pass through a conductor where the number density of free electrons is $4 \times 1028\ m^{-3}$ and its area of cross-section is $10^{-5}\ m^2$, Find out the value of the drift velocity of free electrons.
(A) 25×10^{-4}m/s (B) 2.5×10^{-4} m/s (C) 5×10^{-4} m/s (D) 0.5×10^{-4} m/s

3. Consider the figure, cross-sectional area of conductor at *A* and *B* is 2*a* and *a* respectively. Current density at *A* and *B* are given by J_A and J_B then J_A/J_B is -



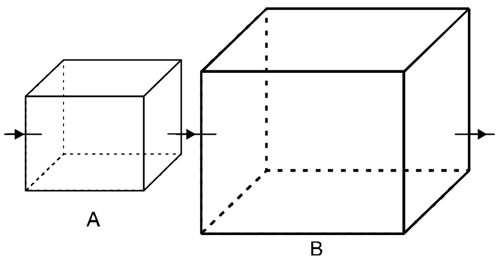
(A) $\frac{1}{2}$ (B) 2 (C) 1 (D) 4

4.* A metallic conductor of irregular cross-section is as shown in the figure. A constant potential difference is applied across the ends (A) and (B). Then :



(A) the current at the cross-section P equals the current at the cross-section Q
(B) the electric field intensity at P is less than that at Q.
(C) the rate of heat generated per unit time at Q is greater than that at P
(D) the number of electrons crossing per unit time per unit area of cross-section at P is less than that at Q.

5. Two square metal plates A and B are of the same thickness and material. The side of B is twice that of A. These are connected as shown in Figure. (series connection).If R_A and R_B are the resistances of A and B, respectively, then $\frac{R_A}{R_B}$ is

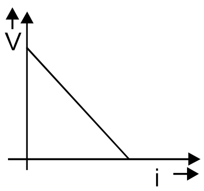


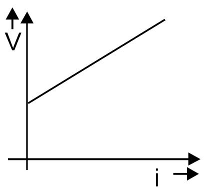
(A) 1 :2 (B) 2 : 1 (C) 1 :1 (D) 4 : 1

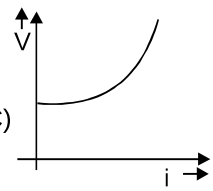
6. The equivalent resistance of a group of resistances is R. If another resistance is connected in parallel to the group , its new equivalent becomes R_1 & if it is connected in series to the group , its new equivalent becomes R_2 we have :

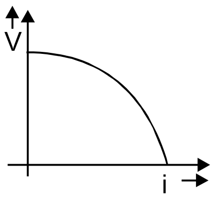
(A) $R_1 > R$ (B) $R_1 < R$ (C) $R_2 > R$ (D) $R_2 < R$

7. If internal resistance of a cell is proportional to current drawn from the cell. Then the best representation of terminal potential difference of a cell with current drawn from cell will be:

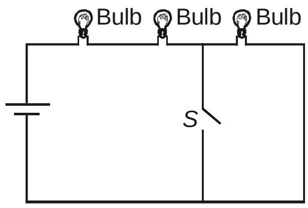
(A) 

(B) 

(C) 

(D) 

8. In the circuit shown, the total power output is *P* when *S* is closed. As the switch *S* is opened, the power output becomes (all bulbs are identical)

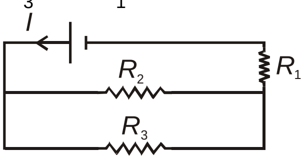


(A) $\frac{2}{3}$P (B) $\frac{3}{2}$P (C) $\frac{4}{9}$P (D) $\frac{9}{4}$P

9. Three 60 W light bulbs are mistakenly wired in series and connected to a 120 V power supply. Assume the light bulbs are rated for single connection to 120 V. With the mistaken connection, the power dissipated by each bulb is :

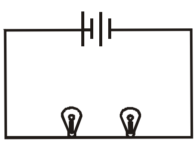
(A) 6.7 W (B) 13.3 W (C) 20 W (D) 40 W

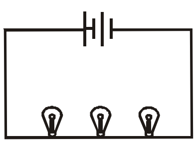
10. Refer to the circuit shown. What will be the total power dissipation in the circuit if *P* is the power dissipated in R_1? It is given that $R_2 = 4\ R_1$ and $R_3 = 12\ R_1$

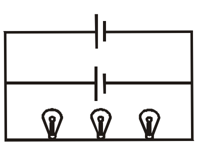


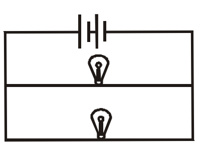
(A) 4 *P* (B) 7 *P* (C) 13 *P* (D) 17 *P*

11. In the diagrams, all light bulbs are identical, all cells are ideal and identical. In which circuit bulbs are dimmest

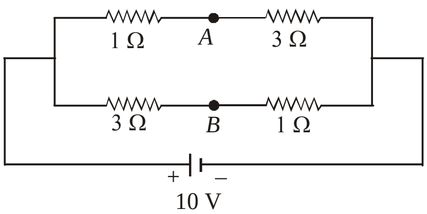
(A) 

(B) 

(C) 

(D) 

12. A battery of *e.m.f.* 10 V is connected to resistances as shown in the figure. The potential difference between A and B is



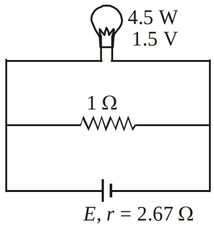
(A) –2 V

(B) +2 V

(C) –5 V

(D) 5 V

13. A torch bulb rated as 4.5 W, 1.5 V is connected as shown in the figure. The e.m.f. of the cell of internal resistance 2.67 Ω, needed to make the bulb glow at full intensity is



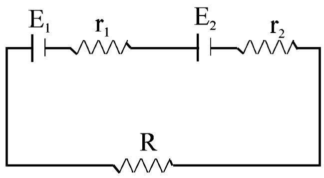
(A) 4.5 V

(B) 6.75 V

(C) 13.5 V

(D) 27 V

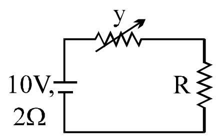
14. Under what condition current passing through the resistance R can be increased by short circuiting the battery of emf E_2. The internal resistances of the two batteries are r_1 and r_2 respectively.



(A) $E_2r_1 > E_1 (R + r_2)$ (B) $E_1r_2 > E_2 (R + r_1)$

(C) $E_2r_2 > E_1 (R + r_2)$ (D) $E_1r_1 > E_2 (R + r_1)$

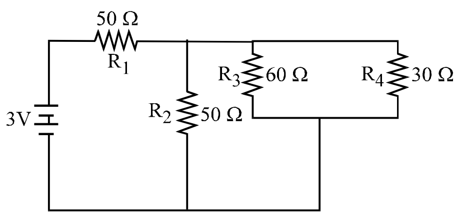
15. In the figure shown the power generated in y is maximum when y = 5Ω. Then R is



(A) 2 Ω (B) 6 Ω

(C) 5 Ω (D) 3 Ω

16. In the circuit shown, the resistances are given in ohms and the battery is assumed ideal with emf equal to 3.0 volts. The resistor that dissipates the most power is



(A) R_1 (B) R_2

(C) R_3 (D) R_4

17. What amount of heat will be generated in a coil of resistance R due to a charge q passing through it if the current in the coil decreases to zero uniformly during a time interval Δt

(A) $\frac{4}{3}\frac{q^2R}{\Delta t}$ (B) $ln\frac{q^2R}{2\Delta t}$ (C) $\frac{2q^2R}{3\Delta t}$ (D) ln$\frac{(2\Delta t)}{q^2R}$

18. The variation of current (I) and voltage (V) is as shown in figure A. The variation of power P with current I is best shown by which of the following graph

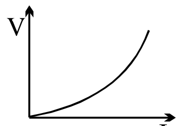
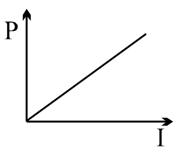
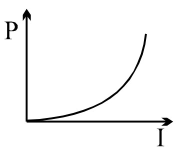
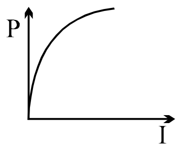
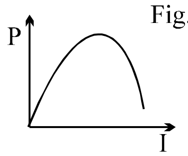


Fig. A

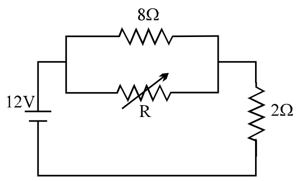
(A) 

(B) 

(C) 

(D) 

19.* The value of the resistance R in figure is adjusted such that power dissipated in the 2Ω resistor is maximum. Under this condition



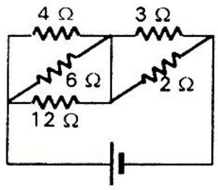
(A) R = 0

(B) R = 8Ω

(C) power dissipated in the 2 Ω resistor is 72 W.

(D) power dissipated in the 2 Ω resistor is 8 W.

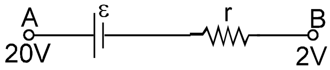
20. The resistor in which the maximum heat is produced is given by



(A) 2Ω (B) 3Ω

(C) 4Ω (D) 12Ω

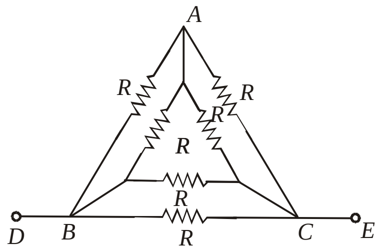
21. In the figure a part of circuit is shown :



(A) current will flow from A to B (B) current may flow from A to B

(C) current will flow from B to A (D) the direction of current will depend on *r*.

22. The resistance across points D and E of the circuit is



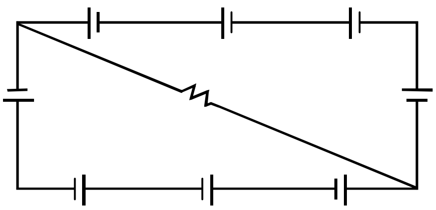
(A) $R/2$

(B) $R/3$

(C) $R/4$

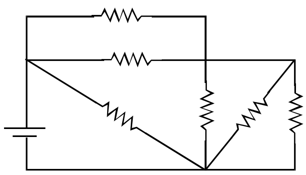
(D) $2R$

23. A circuit is comprised of eight identical batteries and a resistor R = 0.8 Ω . Each battery has an emf of 1.0 V and internal resistance of 0.2 Ω . The voltage difference across any of the battery is:



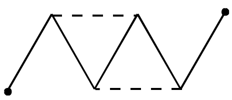
(A) 0.5 V (B) 1.0 V (C) 0 V (D) 2 V

24. In the figure shown each resistor is of 20 Ω and the cell has emf 10 volt with negligible internal resistance. Then rate of joule heating in the circuit is (in watts)



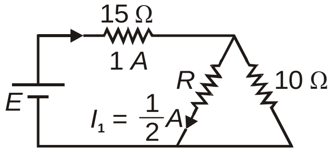
(A) 100/11 (B) 10000/11 (C) 11 (D) None of these

25. Five identical resistors each of resistance 1 Ω are initially arranged as shown in the figure by clear lines. If two similar resistances are added as shown by the dashed lines then change in resistance in initial and final arrangement is



(A) 2 Ω (B) 1 Ω (C) 3 Ω (D) 4 Ω

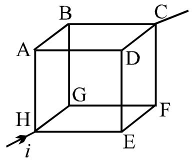
26. In the circuit shown in the figure, the value of E is equal to



(A) 20 V (B) 10 V

(C) 5 V (D) 30 V

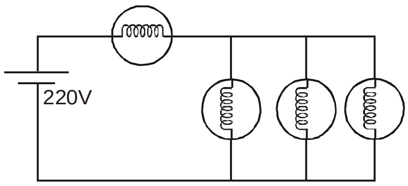
27. In the box shown current i enters at H and leaves at C. If $i_{AB} = \frac{i}{6}$, $i_{DC} = \frac{2i}{3}$,



$i_{HA} = \frac{i}{2}$, $i_{GF} = \frac{i}{6}$, $i_{HE} = \frac{i}{6}$, choose the branch in which current is zero

(A) BG (B) FC (C) ED (D) none

28. Four identical bulbs each rated 100 watt, 220 volts are connected across a battery as shown. The total electric power consumed by the bulbs is:

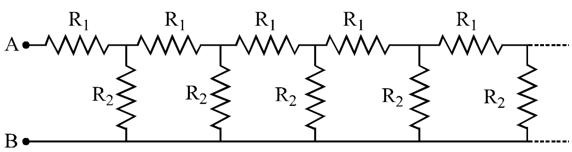


(A) 75 watt (B) 400 watt (C) 300 watt (D) 400/3 watt

29. Power generated across a uniform wire connected across a supply is H. If the wire is cut into n equal parts and all the parts are connected in parallel across the same supply, the total power generated in the wire is

(A) $\frac{H}{n^2}$ ` (B) n^2H (C) nH (D) $\frac{H}{n}$

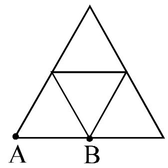
30. Consider an infinte ladder network shown in figure. A voltage V is applied between the points A and B. This applied value of voltage is halved after each section.



(A) $R_1/R_2 = 1$ (B) $R_1/R_2 = 1/2$

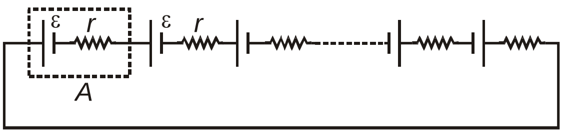
(C) $R_1/R_2 = 2$ (D) $R_1/R_2 = 3$

31. In the diagram resistance between any two junctions is R. Equivalent resistance across terminals A and B is



(A) $\frac{11R}{7}$ (B) $\frac{18R}{11}$ (C) $\frac{7R}{11}$ (D) $\frac{11R}{18}$

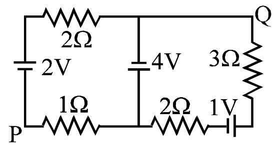
32. In a arrangement, 3n cells of emf ε and internal resistance r are connected in series. Out of 3n cells, polarity of n cells is reversed.



Current in the circuit is

(A) $\frac{2\varepsilon}{r}$ (B) $\frac{2\varepsilon}{3r}$ (C) $\frac{\varepsilon}{3r}$ (D) $\frac{\varepsilon}{r}$

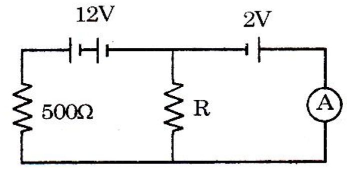
33. In the circuit shown, what is the potential difference V_{PQ}?



(A) + 3V (B) + 2V

(C) –2V (D) none

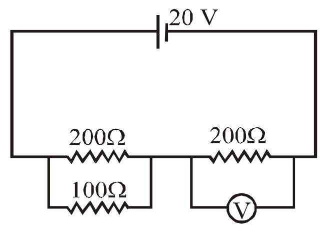
34. In the given circuit the ammeter reading is zero. What is the value of resistance R ?



(A) R = 100Ω (B) R = 10Ω

(C) R = 0.1Ω (D) None of these

35. In the following circuit, the reading of the voltmeter (ideal) is



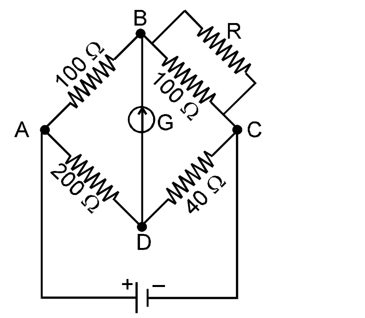
(A) 5 V

(B) 10 V

(C) 15 V

(D) 16.5 V

36. The given Wheatstone bridge is showing no deflection in the galvanometer joined between the points B and D (Figure). Calculate the value of R.



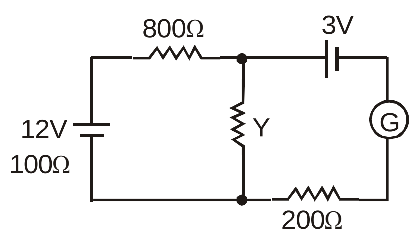
(A) 25 Ω

(B) 50 Ω

(C) 40 Ω

(D) 100 Ω

37. If galvanometer shows null deflection in the given figure then the value of Y is



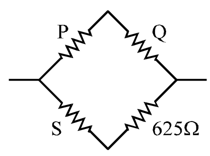
(A) 100 Ω

(B) 200 Ω

(C) 300 Ω

(D) 400 Ω

38. A Wheatstone's bridge is balanced with a resistance of 625 Ω in the third arm, where P, Q and S are in the 1st, 2nd and 4th arm respectively. If P and Q are interchanged, the resistance in the third arm has to be increased by 51Ω to secure balance. The unknown resistance in the fourth arm is



(A) 625 Ω (B) 650 Ω

(C) 676 Ω (D) 600 Ω

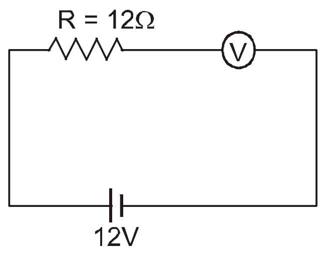
39. In a balanced wheat stone bridge, current in the galvanometer is zero. It remains zero when:

[1] battery emf is increased
[2] all resistances are increased by 10 ohms
[3] all resistances are made five times
[4] the battery and the galvanometer are interchanged

(A) only [1] is correct (B) [1], [2] and [3] are correct

(C) [1], [3] and [4] are correct (D) [1] and [3] are correct

40. By error, a student places moving-coil voltmeter V (nearly ideal) in series with the resistance in a circuit in order to read the current, as shown. The voltmeter reading will be



(A) 0 (B) 4V

(C) 6V (D) 12V

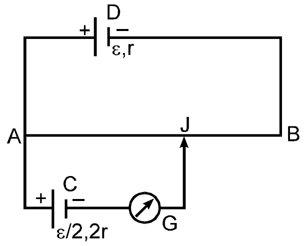
41. Two cells of e.m.f. E_1 and E_2 are joined in series and the balancing length of the potentiometer wire is 875 cm. If the terminals of E_1 are reversed, the balancing length obtained is 175 cm. Given $E_2 > E_1$, the ratio $E_1 : E_2$ will be

(A) 2 : 3 (B) 5 : 1 (C) 3 : 2 (D) 1 : 5

42. The emf of driver cell in a potentiometer circuit is 10 V. The length of potentiometer wire is 1 m and its resistance is 9 Ω. A cell of emf 5 V is balanced on $\frac{5}{9}$ m length of the wire. The internal resistance of the driver cell is

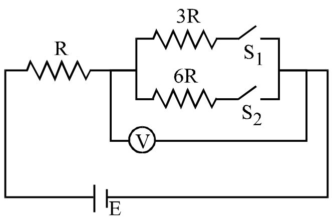
(A) 1 Ω (B) 0.1 Ω (C) 2 Ω (D) 0.5 Ω

43. In the fig. the potentiometer wire AB of length L & resistance 9 r is joined to the cell D of e.m.f. ε & internal resistance r. The cell C's e.m.f. is $\varepsilon/2$ and its internal resistance is 2 r. The galvanometer G will show no deflection when the length AJ is:



(A) 4L/9 (B) 5L/9 (C) 7L/18 (D) 11L/18

44. In the circuit shown in figure reading of voltmeter is V_1 when only S_1 is closed, reading of voltmeter is V_2 when only S_2 is closed. The reading of voltmeter is V_3 when both S_1 and S_2 are closed then

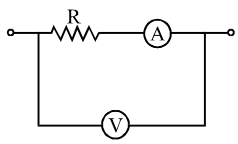


(A) $V_2 > V_1 > V_3$ (B) $V_3 > V_2 > V_1$

(C) $V_3 > V_1 > V_2$ (D) $V_1 > V_2 > V_3$

45. In the circuit shown the resistance of voltmeter is 10,000 ohm and that of ammeter is 20 ohm. The ammeter reading is 0.10 Amp and voltmeter reading is 12 volt.

Then R is equal to

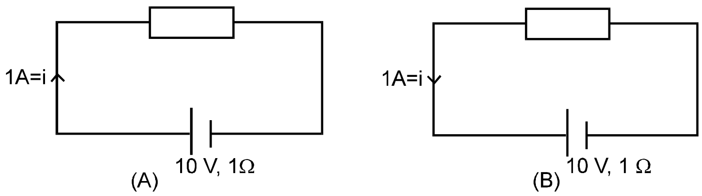


(A) 122 Ω (B) 140 Ω (C) 116 Ω (D) 100 Ω

PART - II : SUBJECTIVE QUESTIONS

1. The current through a wire depends on time as $i = i_0 + \alpha \sin \pi t$, where $i_0 = 10$ A and $\alpha = \frac{\pi}{2}$ A. Find the charge crossed through a section of the wire in 3 seconds, and average current for that interval.

2. In following diagram boxes may contain resistor or battery or any other element



then determine in each case

(a) E.m.f. of battery

(b) Battery is acting as a source or load

(c) Potential difference across each battery

(d) Power input to the battery or output by the battery.

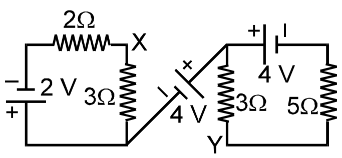
(e) The rate at which heat is generated inside the battery.

(f) The rate at which the chemical energy of the cell is consumed or increased.

(g) Potential difference across box

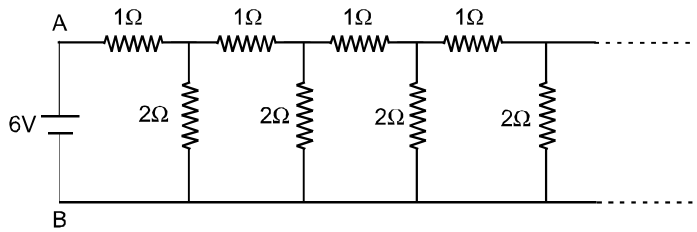
(h) Electric power output across box.

3. (a) Determine the potential difference between X and Y in the circuit shown in Figure.



(b) If intermediate cell has internal resistance r = 1Ω then determine the potential difference between X and Y.

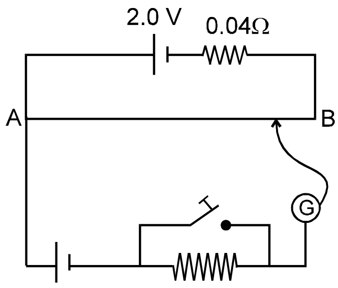
4. An infinite ladder network of resistance is constructed with 1Ω and 2Ω resistance, as shown in figure.



(i) Show that the effective resistance between A and B is 2Ω.

(ii) What is the current that passes through the 2Ω resistance nearest to the battery ?

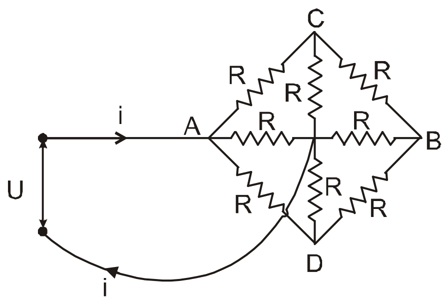
5. Figure shows a potentiometer with a cell of emf 2.0 V and internal resistance 0.04 Ω maintaining a potential drop across the potentiometer wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents up to a few ampere) gives a balance point of 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf E and the balance point found similarly turns out to be at 82.3 cm length of the wire.



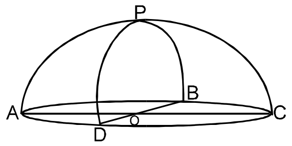
(a) What is the value of E ?
(b) What purpose does the high resistance of 600 kΩ have ?
(c) Is the balance point affected by this high resistance?
(d) Is the balance point affected by the internal resistance of the driver cell?
(e) Would the method work in the above situation if the driver cell of the potentiometer had an emf of 1.0 V instead of 2.0 V?
(f) Would the circuit work well for determining extremely small emf, say, of the order of few mV (such typical emf of thermocouple)?

6. ABCD is a square where each side is uniform wire of resistance 1 Ω. Find a point E on CD such that if a uniform wire of resistance 1 Ω is connected across AE and a constant potential difference is applied across A and C, the points B and E will be equipotential.

7. The resistance of each resistor in the circuit diagram shown in figure is the same and equal to R. The voltage across the terminals is U. Determine the current I in the leads if their resistance can be neglected.



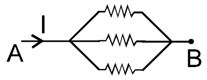
8. A hemispherical network of radius a is made by using a conducting wire of resistance per unit length 'r'. Find the equivalent resistance across OP.

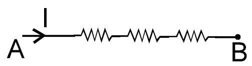


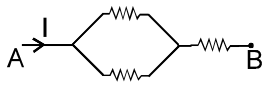
EXERCISE # 3

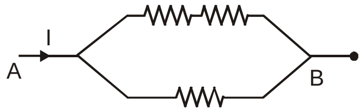
PART-I IIT-JEE (PREVIOUS YEARS PROBLEMS)

1. Arrange the order of power dissipated in the given circuits, if the same current is passing through the system. The resistance of each resistor is 'r'. **[IIT-JEE(Scr.) - 2003, 3/84]**

(i) 

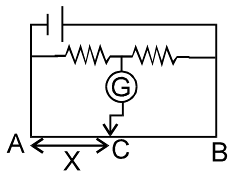
(ii) 

(iii) 

(iv) 

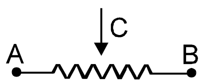
(A) $P_2 > P_3 > P_4 > P_1$ (B) $P_1 > P_4 > P_3 > P_2$ (C) $P_1 > P_2 > P_3 > P_4$ (D) $P_4 > P_3 > P_2 > P_1$

2. In the given circuit, no current is passing through the galvanometer. If the cross-sectional diameter of the wire AB is doubled, then for null point of galvanometer, the value of AC would be: **[IIT-JEE(Scr.) - 2003, 3/84]**

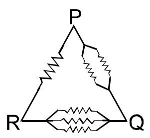


(A) 2 X (B) X (C) $\frac{X}{2}$ (D) None

3. Connect a battery to the terminals and complete the circuit diagram so that it works as a potential divider meter. Indicate the output terminals also. **[IIT-JEE(Main) - 2003, 2/60]**

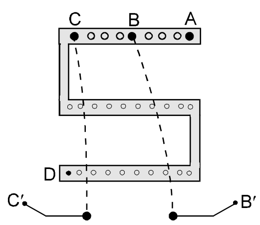


4. In the given circuit all resistors are of equal value then equivalent resistance will be maximum between the points. **[IIT-JEE(Scr.) - 2004, 3/84]**



(A) PR (B) PQ (C) RQ (D) same for all

5. Between which points should the terminals of unknown resistance be connected in a post office box arrangement to get its value **[IIT-JEE(Scr.) - 2004, 3/84]**

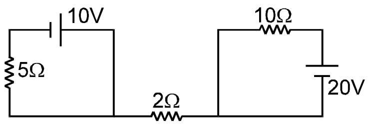


(A) A and B (B) B and C (C) C and D (D) A andD

6. Draw the circuit diagram for the verification of ohm's law using resistance R = 100Ω. Using galvanometers, and resistances of 10^{-3} Ω and 10^{+6} Ω, clearly indicating the position of ammeter & voltmeter.

[IIT-JEE(Main) - 2004, 4/60]

7. In the figure shown the current through 2Ω resistor is **[IIT-JEE (Scr.) - 2005, 3/84]**

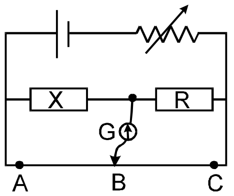


(A) 2A (B) 0 A (C) 4 A (D) 6A

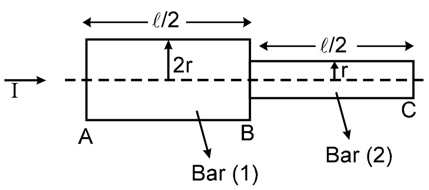
8. A galvanometer has resistance 100Ω and it requires current 100μA for full scale deflection. A resistor 0.1Ω is connected in parallel to make it an ammeter. The smallest current required in the circuit to produce the full scale deflection is

(A) 1000.1 mA (B) 1.1 mA (C) 10.1 mA (D) 100.1 mA

9. For the three values of resistances R namely R_1, R_2 and R_3 the balanced positions of jockey are at A, B and C respectively as shown in figure. Which position will show most accurate result for calculation of X. Give reason. B is near the mid point of the wire. **[IIT-JEE (Main)' 2005, 2/60]**



10. Two bars of equal resistivity ρ and radii 'r' and '2r' are kept in contact as shown. An electric current I is passed through the bars. Which one of the following is correct? **[IIT-JEE 2006; 3/184]**



(A) Heat produced in bar (1) is 2 times the heat produced in bar (2)

(B) Electric field in both halves is equal

(C) Current density across AB is double that across BC.

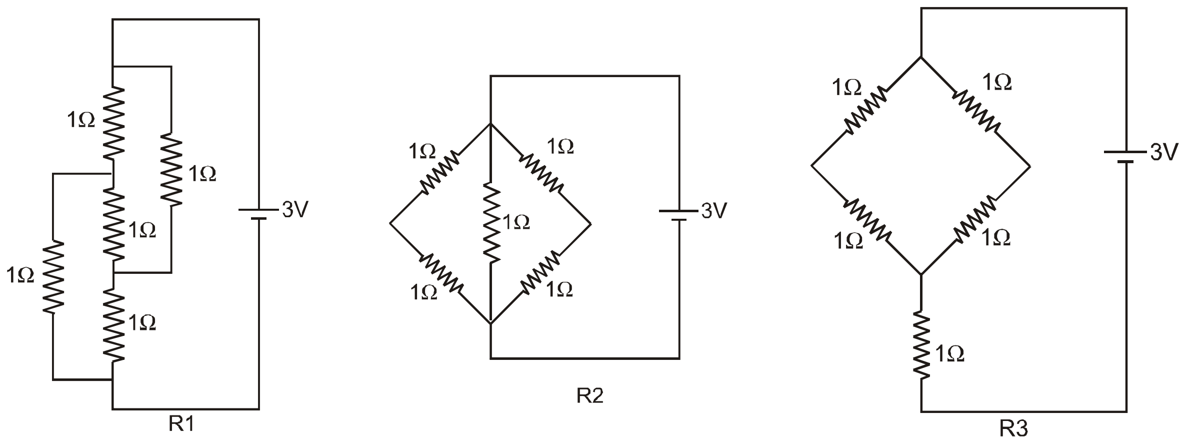
(D) Potential difference across BC is 4 times that across AB.

11. A resistance of 2 Ω is connected across one gap of a metre-bridge (the length of the wire is 100 cm) and an unknown resistance, greater than 2 Ω, is connected across the other gap. When these resistances are interchanged, the balance point shifts by 20 cm. Neglecting any corrections, the unknown resistance is

[IIT-JEE 2007; Paper-1, 3/81]

(A) 3 Ω (B) 4 Ω (C) 5 Ω (D) 6 Ω

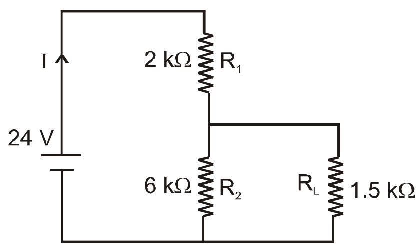
12. Figure shows three resistor configurations R1, R2 and R3 connected to 3 V battery. If the power dissipated by the configuration R1, R2 and R3 is P1, P2 and P3, respectively, then
Figure : **[IIT-JEE 2008, Paper-1, 3/163]**



(A) P1 > P2 > P3
(B) P1 > P3 > P2
(C) P2 > P1 > P3
(D) P3 > P2 > P1

13. **STATEMENT -1 :** In a Meter Bridge experiment, null point for an unknown resistance is measured. Now, the unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of the standard resistance.
STATEMENT -2 : Resistance of a metal increases with increase in temperature. **[IIT-JEE 2008, Paper-1, 3/163]**
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

14*. For the circuit shown in the figure **[IIT-JEE 2009; 4/160, –1]**



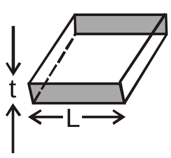
(A) the current I through the battery is 7.5 mA

(B) the potential difference across R_L is 18 V

(C) ratio of powers dissipated in R_1 and R_2 is 3

(D) if R_1 and R_2 are interchanged, magnitude of the power dissipated in R_L will decrease by a factor of 9

15. Consider a thin square sheet of side L and thickness t, made of a material of resitivity ρ. The resistance between two opposite faces, shown by the shaded areas in the figure is : **[IIT-JEE 2010; 3/163, –1]**

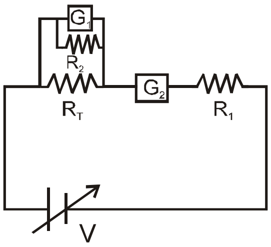


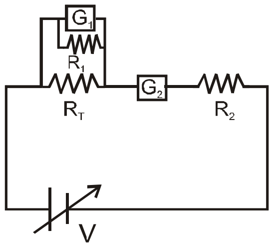
(A) directly proportional to L
(B) directly proportional to t
(C) independent of L
(D) independent of t

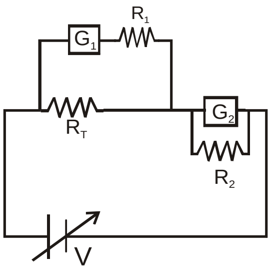
16. Incandescent bulbs are designed by keeping in mind that the resistance of their filament increases with increase in temperature. If at room temperature, 100 W, 60 W and 40 W bulbs have filament resistances R_{100}, R_{60} and R_{40}, respectively, the relation between these resistance is : **[IIT-JEE 2010; 3/163, –1]**

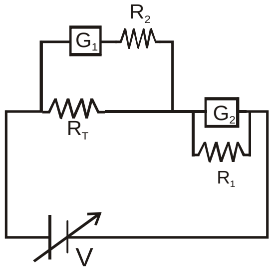
(A) $\frac{1}{R_{100}} = \frac{1}{R_{40}} + \frac{1}{R_{60}}$ (B) $R_{100} = R_{40} + R_{60}$ (C) $R_{100} > R_{60} > R_{40}$ (D) $\frac{1}{R_{100}} > \frac{1}{R_{60}} > \frac{1}{R_{40}}$

17. To verify Ohm's law, a student is provided with a test resistor R_T, a high resistance R_1, a small resistance R_2, two identical galvanometers G_1 and G_2, and a variable voltage source V. The correct circuit to carry out the experiment is : **[IIT-JEE 2010; 3/163, –1]**

(A)


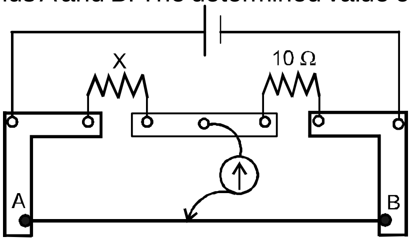
(B)


(C)


(D)


18. When two identical batteries of internal resistance 1Ω each are connected in series across a resistor R, the rate of heat produced in R is J_1. When the same batteries are connected in parallel across R, the rate is J_2. If $J_1 = 2.25\ J_2$ the value of R in Ω is : **[IIT-JEE 2010; 3/163]**

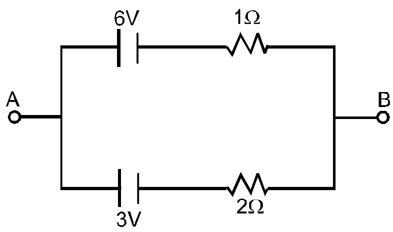
19. A meter bridge is set-up as shown, to determine an unknown resistance 'X' using a standard 10 ohm resistor. The galvanometer shows null point when tapping-key is at 52 cm mark. The end-corrections are 1 cm and 2 cm respectively for the ends A and B. The determined value of 'X' is



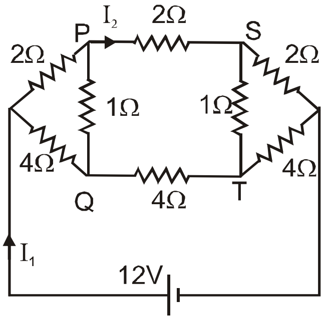
[IIT-JEE 2011; 3/160,–1 conducted by IIT Kanpur]

(A) 10.2 ohm (B) 10.6 ohm (C) 10.8 ohm (D) 11.1 ohm

20. Two batteries of different emfs and different internal resistances are connected as shown. The voltage across AB in volts is **[IIT-JEE 2011; 4/160,0 conducted by IIT Kanpur]**



21. For the resistance network shown in the figure, choose the correct option(s).



(A) The current through PQ is zero. (B) $I_1 = 3A$

(C) The potential at S is less than that at Q. (D) $I_2 = 2A$

PART-II AIEEE (PREVIOUS YEARS PROBLEMS)

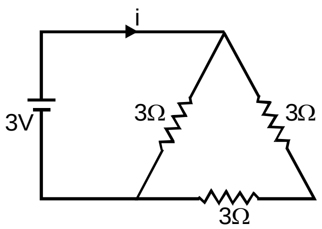
1. The thermo-emf of a thermocouple is 25 μV/ºC at room temperature. A galvanometer of 40 ohm resistance, capable of detecting current as low as 10^{-5} A, is connected with the thermocouple. The smallest temperature difference that can be detected by this system is : **[AIEEE 2003, 4/300]**

(1) 16ºC (2) 12ºC (3) 8ºC (4) 20ºC

2. A 220 volt, 1000 watt bulb is connected across a 110 volt mains supply. The power consumed will be- **[AIEEE 2003, 4/300]**

(1) 750 watt (2) 500 watt (3) 250 watt (4) 1000 watt

3. A 3 volt battery with negligible internal resistance is connected in a circuit as shown in the figure. Current i will be :



[AIEEE 2003, 4/300]

(1) 1/3 A (2) 1 A (3) 1.5 A (4) 2 A

4. An ammeter reads upto 1 ampere. Its internal resistance is 0.81 ohm. To increase the range to 10 A the value of the required shunt is : **[AIEEE 2003, 4/300]**

(1) 0.09 Ω (2) 0.03 Ω (3) 0.3 Ω (4)0.9 Ω

5. A strip of copper and another of germanium are cooled from room temperature to 80 K. The resistance of **[AIEEE 2003, 4/300]**

(1) Each of these increases

(2) Each of these decreases

(3) Copper strip increases and that of germanium decreases

(4) Copper strip decreases and that of germanium increases

6. The length of a wire of a potentiometer is 100 cm, and the emf of its standard cell is E volt. It is employed to measure the emf of a battery whose internal resistance is 0.5 ohm. If the balance point is obtained at 30 cm from the positive end, the emf of the battery is **[AIEEE 2003, 4/300]**

(1) $\frac{30E}{100}$ (2) $\frac{30E}{100.5}$ (3) $\frac{30E}{(100-0.5)}$

(4) $\frac{30(E-0.5i)}{100}$, $\frac{30(E-0.5i)}{100}$, where i is the current in the potentiometer

7. The length of a given cylindrical wire is increased by 100%. Due to the consequent decrease in diameter the change in the resistance of the wire will be : **[AIEEE 2003, 4/300]**

(1) 300 % (2) 200 % (3) 100 % (4) 50 %

8. Time taken by a 836 W heater to heat one litre of water from 10ºC to 40ºC is : **[AIEEE 2004, 4/300]**

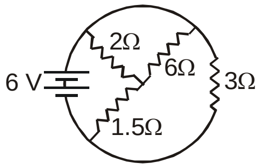
(1) 50 s (2) 100 s (3) 150 s (4) 200 s

9. The thermo–emf of a thermocouple varies with the temperature θ of the hot junction as $E = a\theta + b\theta^2$ in volts where the ratio a/b is 700ºC. If the cold junction is kept at 0ºC, then the neutral temperature

(1) 700ºC (2) 350ºC (3) 1400ºC **[AIEEE 2004, 4/300]**

(4) No neutral temperature is possible for this thermocouple

10. The total current supplied to the circuit by the battery is : **[AIEEE 2004, 4/300]**



(1) 1 A (2) 2 A (3) 4 A (4) 6 A

11. The resistance of the series combination of two resistances is S. When they are joined in parallel, the total resistance is P. If S = nP, then the minimum possible value of n is : **[AIEEE 2004, 4/300]**

(1) 4 (2) 3 (3) 2 (4) 1

12. An electric current is passed through a circuit containing two wires of the same material, connected in parallel. If the lengths and radii of the wires are in the ratio of 4/3 and 2/3, then the ratio of the currents passing through the wire will be : **[AIEEE 2004, 4/300]**

(1) 3 (2) 1/3 (3) 8/9 (4) 2

13. In a metre bridge experiment, null point is obtained at 20 cm from one end of the wire when resistance X is balanced against another resistance Y. If X < Y, then where will be the new position of the null point from the same end, if one decides to balance a resistance of 4X against Y ? **[AIEEE 2004, 4/300]**

(1) 50 cm (2) 80 cm (3) 40 cm (4) 70 cm

14. Two voltameters, one of copper and another of silver, are joined in parallel. When a total charge q flows through the voltameters, equal amount of metals are deposited. If the electrochemical equivalents of copper and silver are z_1 and z_2 respectively, the charge which flows through the silver voltameter is :

[AIEEE 2005, 4/300]

(1) $\frac{q}{1+\frac{z_1}{z_2}}$ (2) $\frac{q}{1+\frac{z_2}{z_1}}$ (3) $q\frac{z_1}{z_2}$ (4) $q\frac{z_2}{z_1}$

15. Two sources of equal emf are connected to an external resistance R. The internal resistances of the two sources are R_1 and $R_2 (R_2 > R_1)$. If the potential difference across having internal resistance R_2, is zero, then: **[AIEEE 2005, 4/300]**

(1) $R = \frac{R_2 \times (R_1 + R_2)}{(R_2 - R_1)}$ (2) $R = R_2 - R_1$ (3) $R = \frac{R_1 R_2}{(R_2 + R_1)}$ (4) $R = \frac{R_1 R_2}{(R_2 - R_1)}$

16. A heater coil is cut into two equal parts and only one part is now used in the heater. The heat generated will now be : **[AIEEE 2005, 4/300]**

(1) doubled (2) four times (3) one-fourth (4) half

17. In a potentiometer experiment the balancing with a cell is at length 240 cm. On shunting the cell with a resistance of 2Ω, the balancing length becomes 120 cm. The internal resistance of the cell is : **[AIEEE 2005, 4/300]**

(1) 1 Ω (2) 0.5 Ω (3) 4 Ω (4) 2 Ω

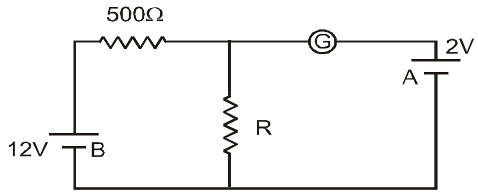
18. The resistance of hot tungsten filament is about 10 times the cold resistance. What will be the resistance of 100 W and 200 V lamp when not in use : **[AIEEE 2005, 4/300]**

(1) 40 Ω (2) 20 Ω (3) 400 Ω (4) 200 Ω

19. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milli ampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 volt, the resistance in ohms needed to be connected in series with the coil will be : **[AIEEE 2005, 4/300]**

(1) 10^3 (2) 10^5 (3) 99995 (4) 9995

20. In the circuit, the galvanometer G shows zero deflection. If the batteries A and B have negligible internal resistance, the value of the resistor R will be : **[AIEEE 2005, 4/300]**



(1) 200 Ω (2) 100 Ω (3) 500 Ω (4) 1000 Ω

21. A thermocouple is made from two metals, Antimony and Bismuth. If one junction of the couple is kept hot and the other is kept cold, then, an electric current will **[AIEEE 2006, 3/180]**

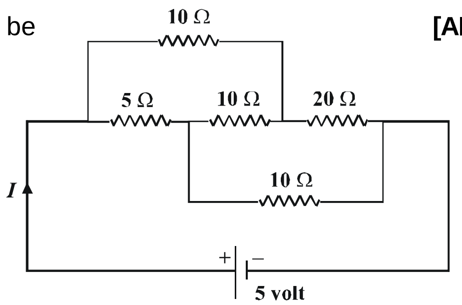
(1) not flow through the thermocouple

(2) flow from Antimony to Bismuth at the cold junction

(3) flow from Antimony to Bismuth at the hot junction

(4) flow from Bismuth to Antimony at the cold junction

22. The current I drawn from the 5 volt source will be **[AIEEE 2006, 3/180]**



(1) 0.67 A

(2) 0.17 A

(3) 0.33 A

(4) 0.5 A

23. In a Wheat stone's bridge, three resistances P, Q and R are connected in the three arms and the fourth arm is formed by two resistances S_1 and S_2 connected in parallel. The condition for the bridge to be balanced will be : **[AIEEE 2006, 3/180]**

(1) $\frac{P}{Q}=\frac{R(S_1+S_2)}{2S_1S_2}$ (2) $\frac{P}{Q}=\frac{R}{S_1+S_2}$ (3) $\frac{P}{Q}=\frac{2R}{S_1+S_2}$ (4) $\frac{P}{Q}=\frac{R(S_1+S_2)}{S_1S_2}$

24. The resistance of bulb filament is 100 Ω at a temperature of 100ºC. If its temperature coefficient of resistance be 0.005 per ºC, its resistance will become 200 Ω at a temperature of **[AIEEE 2006, 3/180]**

(1) 500ºC (2) 200ºC (3) 300ºC (4) 400ºC

25. An electric bulb is rated 220 volt - 100 watt. The power consumed by it when operated on 110 volt will be

(1) 25 watt (2) 50 watt **[AIEEE 2006, 4½/180]**

(3) 75 watt (4) 40 watt

26. A material 'B' has twice the specific resistance of 'A'. A circular wire made of 'B' has twice the diameter of a wire made of 'A'. Then for the two wires to have the same resistance, the ratio ℓ_A/ℓ_B of their respective lengths must be **[AIEEE 2006, 1½/180]**

(1) 2 (2) 1 (3) 1/2 (4) 1/4

27. The Kirchhoff's first law $\left(\sum i=0\right)$ and second law $\left(\sum iR=0=\sum E\right)$, where the symbols have their usual meanings, are respectively based on **[AIEEE 2006, 1½/180]**

(1) conservation of charge, conservation of energy

(2) conservation of charge, conservation of momentum

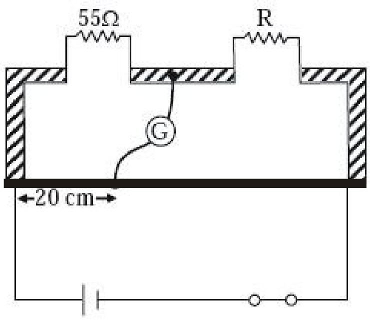
(3) conservation of energy, conservation of charge

(4) conservation of momentum, conservation of charge

28. The resistance of a wire is 5 ohm at 50° C and 6 ohm at 100°C. The resistance of the wire at 0°C will be

(1) 2 ohm (2) 1 ohm (3) 4 ohm (4) 3 ohm **[AIEEE 2007, 3/120]**

29. Shown in the figure below is a meter-bridge set up with null deflection in the galvanometer.

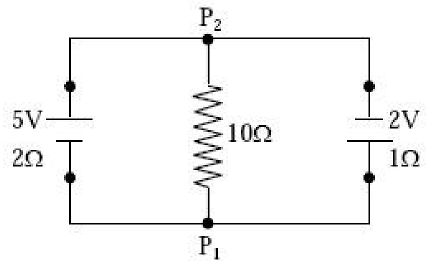


The value of the unknown resistor R is **[AIEEE 2008, 3/105]**

(1) 220 Ω (2) 110 Ω (3) 55 Ω (4) 13.75 Ω

30. A 5 V battery with internal resistance 2 Ω and a 2V battery with internal resistance 1Ω are connected to a 10Ω resistor as shown in the figure. **[AIEEE 2008, 3/105]**

The current in the 10 Ω resistor is -



(1) 0.03 A P_1 to P_2

(2) 0.03 A P_2 to P_1

(3) 0.27 A P_1 to P_2

(4) 0.27 A P_2 to P_1

31. Two conductors have the same resistance at 0°C but their temperature coefficients of resistance are α_1 and α_2. The respective temperature coefficients of their series and parallel combinations are nearly **[AIEEE 2010, 8/144]**

(1) $\frac{\alpha_1+\alpha_2}{2}, \alpha_1+\alpha_2$ (2) $\alpha_1+\alpha_2, \frac{\alpha_1+\alpha_2}{2}$ (3) $\alpha_1+\alpha_2, \frac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}$ (4) $\frac{\alpha_1+\alpha_2}{2}, \frac{\alpha_1+\alpha_2}{2}$

32. If a wire is stretched to make it 0.1% longer, its resistance will : **[AIEEE-2011, 4/120]**

(1) increase by 0.5% (2) increase by 0.2%

(3) decrease by 0.2% (4) decrease by 0.05%

33. Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3 % each, then error in the value of resistance of the wire is : **[AIEEE-2012, 4/120]**

(1) 3 % (2) 6 % (3) zero (4) 1 %

34. Two electric bulbs marked 25W – 220 V and 100W-220V are connected in series to a 440 V supply. Which of the bulbs will fuse ? **[AIEEE-2012, 4/120]**

(1) neither (2) both (3) 100 W (4) 25 W

35. The supply voltage to a room is 120 V. The resistance of the lead wires is 6Ω. A 60 W bulb is already switched on. What is the decrease of voltage across the bulb, when a 240 W heater is switched on in parallel to the bulb? **[JEE_Mains_2013]**

(1) zero Volt (2) 2.9 Volt (3) 13.3 Volt (4) 10.04 Volt

36. This question has Statement I and Statement II. Of the four choice given after the Statements, choose the one that best describes the two Statements. **[JEE_Mains_2013]**

Statement-I : Higher the range, greater is the resistance of ammeter.

Statement-II : To increase the range of ammeter, additional shunt needs to be used across it.

(1) Statement-I is true; Statement-II is true, Statement-II is the correct explanation of Statement-I.

(2) Statement-I is true; Statement-II is true, Statement-II is not the correct explanation of Statement-I.

(3) Statement-I is true; Statement-II is false.

(4) Statement-I is false; Statement-II is true.

EXERCISE # 4

PART - I : BOARD PATTERN QUESTIONS

1. The storage battery of a car has an emf of 12 V. If the internal resistance of the battery is 0.4 Ω, what is the maximum current that can be drawn from the battery?

2. A battery of emf 10 V and internal resistance 3 Ω is connected to a resistor. If the current in the circuit is 0.5 A, what is the resistance of the resistor? What is the terminal voltage of the battery when the circuit is closed?

3. (a) Three resistors 1 Ω, 2 Ω, and 3 Ω are combined in series. What is the total resistance of the combination?
(b) If the combination is connected to a battery of emf 12 V and negligible internal resistance, obtain the potential drop across each resistor.

4. (a) Three resistors 2 Ω, 4 Ω and 5 Ω are combined in parallel. What is the total resistance of the combination?
(b) If the combination is connected to a battery of emf 20 V and negligible internal resistance, determine the current through each resistor, and the total current drawn from the battery.

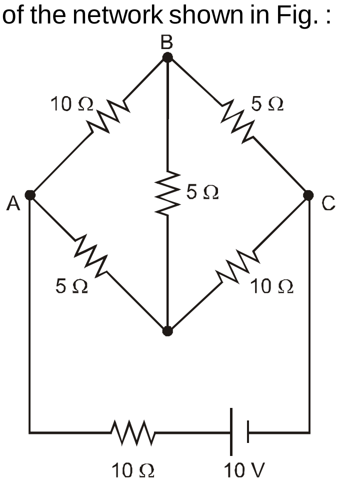
5. At room temperature (27.0°C) the resistance of a heating element is 100 Ω. What is the temperature of the element if the resistance is found to be 117 Ω, given that the temperature coefficient of the material of the resistor is 1.70×10^{-4} °C^{-1}.

6. A negligibly small current is passed through a wire of length 15 m and uniform cross-section 6.0×10^{-7} m^2, and its resistance is measured to be 5.0 Ω. What is the resistivity of the material at the temperature of the experiment?

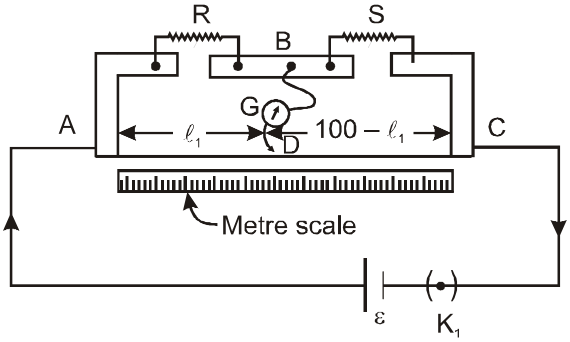
7. A silver wire has a resistance of 2.1 Ω at 27.5°C, and a resistance of 2.7 Ω at 100°C. Determine the temperature coefficient of resistivity of silver.

8. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0°C? Temperature coefficient of resistance of nichrome averaged over the temperature range involved is 1.70×10^{-4} °C^{-1}.

9. Determine the current in each branch of the network shown in Fig. :



10. (a) In a metre bridge figure, the balance point is found to be at 39.5 cm from the end A, when the resistor Y is of 12.5 Ω. Determine the resistance of X. Why are the connections between resistors in a Wheatstone or meter bridge made of thick copper strips?
(b) Determine the balance point of the bridge above if X and Y are interchanged.
(c) What happens if the galvanometer and cell are interchanged at the balance point of the bridge? Would the galvanometer show any current?



A meter bridge. Wire AC is 1 m long. R is a resistance to be measured and S is a standard resistance.

11. A storage battery of emf 8.0 V and internal resistance 0.5 Ω is being charged by a 120 V dc supply using a series resistor of 15.5 Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

12. In a potentiometer arrangement, a cell of emf 1.25 V gives a balance point at 35.0 cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 63.0 cm, what is the emf of the second cell?

ANSWERS

EXERCISE-1

PART - I

* ***Marked Questions are having more than one correct option.***

A-1.	(C)	**A-2.**	(C)	**A-3.**	(C)	**A-4.**	(D)	**A-5.**	(D)	**B-1.**	(B)	**B-2.**	(C)
B-3.	(B)	**B-4.**	(B)	**B-5.**	(B)	**C-1.**	(B)	**C-2.**	(B)	**C-3.**	(A)	**C-4.**	(D)
C-5.	(A)	**C-6.**	(A)	**C-7.**	(A)	**C-8.**	(C)	**C-9.**	(D)	**C-10.**	(C)	**C-11.**	(B)
C-12.	(A)	**C-13.**	(A)	**C-14.**	(A)	**D-1.**	(A)	**D-2.**	(B)	**D-3.**	(A)	**D-4.**	(B)
D-5.	(B)	**D-6.**	(D)	**D-7.**	(A)	**D-8.**	(B)	**D-9.**	(C)	**D-10.**	(A)	**E-1.**	(D)
E-2.	(C)	**E-3.**	(C)	**E-4.**	(A)	**E-5.***	(AC)	**F-1.**	(A)	**F-2.**	(D)	**F-3.**	(A)
F-4.*	(ACD)	**F-5.**	(C)	**F-6.**	(A)	**F-7.**	(A)	**F-8.**	(A)	**F-9.***	(ABC)		

PART - II

1.	(A)	**2.**	(D)	**3.**	(C)	**4.**	(B)	**5.**	(B)	**6.**	(D)	**7.**	(D)
8.	(D)	**9.**	(A)	**10.**	(A) $\rightarrow$ p ; (B) $\rightarrow$ Q ; (C) $\rightarrow$ r ; (D) $\rightarrow$ p ;								

EXERCISE-2

PART - I

1.	(C)	**2.**	(B)	**3.**	(A)	**4.***	(ABCD)	**5.**	(C)	**6.**	(B)(C)	**7.**	(D)
8.	(A)	**9.**	(A)	**10.**	(A)	**11.**	(C)	**12.**	(D)	**13.**	(C)	**14.**	(B)
15.	(D)	**16.**	(A)	**17.**	(A)	**18.**	(B)	**19.***	(AC)	**20.**	(C)	**21.**	(B)
22.	(B)	**23.**	(C)	**24.**	(C)	**25.**	(A)	**26.**	(A)	**27.**	(B)	**28.**	(A)
29.	(B)	**30.**	(B)	**31.**	(D)	**32.**	(C)	**33.**	(B)	**34.**	(A)	**35.**	(C)
36.	(A)	**37.**	(C)	**38.**	(B)	**39.**	(C)	**40.**	(D)	**41.**	(A)	**42.**	(A)
43.	(B)	**44.**	(A)	**45.**	(D)								

PART - II

1. 31 C , $\frac{31}{3}$ A

2. (a) E = 10 V each (b) (A) act as a source and (B) act as load (c) V_A = 9V, V_B = 11 V
(d) P_A = 9 W, P_B = 11 W (e) Heat rate = 1 W each (f) 10 W each (g) 9V, 11V (h) -9W, 11 W

3. (a) 3.7 V (b) 3.7 V **4.** **(ii) 1.5 A**

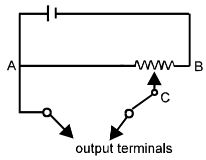
5. (a) 1.25 V, (b) saving of galvanometer from damage and to prevent the cell discharging fast
(c) No, (d) Yes, (e) No, (f) No

6. **Ans.** CE: ED = $\sqrt{2}$: 1 **7.** $i = \frac{15}{7}\frac{U}{R}$ **8.** $\frac{(2+\pi)ar}{8}$

EXERCISE-3

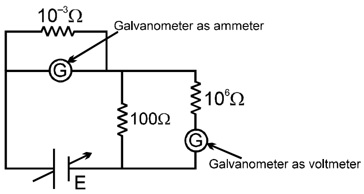
PART - I

1. (A) **2.** (B) **3.**



4. (A) **5.** (D)

6.



7. (B) **8.** (D) **9.** Position B

10. (D) **11.** (A) **12.** (C) **13.** (D) **14*.** (AD) **15.** (C) **16.** (D)

17. (C) **18.** 4 **19.** **(B)** **20.** 5 **21.** (ABCD)

PART - II

1. (1) **2.** (3) **3.** (3) **4.** (1) **5.** (4) **6.** (1) **7.** (1)

8. (3) **9.** (4) **10.** (3) **11.** (1) **12.** (2) **13.** (1) **14.** (2)

15. (2) **16.** (1) **17.** (4) **18.** (1) **19.** (4) **20.** (2) **21.** (4)

22. (4) **23.** (4) **24.** (4) **25.** (1) **26.** (3) **27.** (1) **28.** (3)

29. (1) **30.** (2) **31.** (4) **32.** (2) **33.** (2) **34.** (4) **35.** **(4)**

36. (4)

EXERCISE-4

1. 30 A **2.** 17 Ω, 8.5 V **3.** (a) 6Ω, (b) 2V, 4V, 6V

4. (a) (20/19) Ω, (b) 10A, 5A, 4A ; 19A **5.** 1027°C **6.** 2.0×10^{-7} Ωm

7. $0.0039°C^{-1}$ **8.** 867°C

9. Current in branch AB = (4/17) A,
in BC = (6/17) A, in CD = (–4/17) A,
in AD = (6/17) A, in BD = (–2/17) A, total current = (10/17) A.

10. (a) X = 8.2 Ω ; to minimise resistance of the connection which are not accounted for in the bridge formula.
(b) 60.5 cm from A.
(c) The galvanometer will show no current.

11. 11.5 V ; the series resistor limits the current drawn from the external source. In its absence, the current will be dangerously high.

12. 2.25 V